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Removal of Natural Organic Matter by Anion Exchange: Interactions, Selectivity, and Efficacy Overview

Natural organic matter (NOM), a ubiquitous component of natural waters, is of concern because it poses water treatment challenges and health risks. Anion exchange technology has the potential to be an effective treatment process for the removal of NOM, but an improved understanding of anion exchange treatment is required.

Background

Ion exchange is the process of exchanging charged species in solution phase with charged species in the solid phase. Three anion exchange resins were evaluated for removal of DOC from several raw drinking waters. Figure 1A shows (i) similar removal of DOC by all three resins and (ii) greater DOC removal for Water 1 than in Water 2. Water 1 was characterized by hydrophobic NOM and low ionic strength whereas Water 2 was characterized by hydrophilic NOM and high ionic strength. Figure 1B illustrates that greater reductions in THM4 and HAA9 were achieved by ion exchange treatment (i.e., MIEX) than by conventional treatment (i.e., alum coagulation).

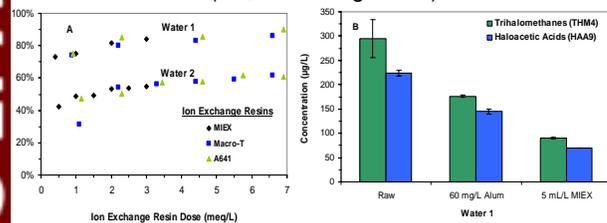


Figure 1. Background Results: **A.** Impact of Raw Water Quality Coagulation versus MIEX

Research Approach

The objective of this research is to elucidate the interactions among NOM, competing inorganic anions, and anion exchange resins. Model waters containing well-characterized NOM extracts (bicarbonate buffer, pH 8) and macroporous, strong-base anion exchange resins will be used in this research. Batch experiments will be used to obtain quantitative equilibrium information such as selectivity coefficients; mini-column experiments will be used to examine the selective removal of different NOM fractions and inorganic anions.

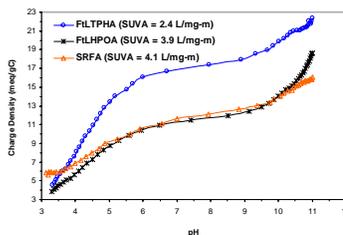


Figure 2 shows the charge density of three NOM extracts, as determined by direct potentiometric titration, and illustrates the trend of increasing charge density with decreasing specific ultraviolet absorbance (SUVA).

Figure 2. Illustrative Acidity Titration Curves

Results & Discussion

The mechanism of NOM uptake is important because it influences NOM-resin and NOM-solvent interactions. Possible mechanisms of NOM uptake by anion exchange resins include ion exchange, surface adsorption, or a combination of ion exchange and surface adsorption. Given the acidity of Suwannee River Fulvic Acid (SRFA; see Figure 2), the mechanism of NOM uptake can be quantified by measuring the exchange of DOC and bicarbonate for chloride.

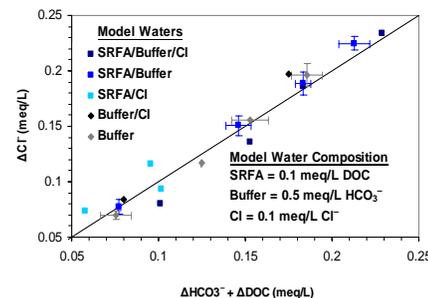


Figure 3. Ion Exchange Stoichiometry

As expected, Figure 3 shows that bicarbonate is removed by ion exchange. In addition, Figure 3 illustrates that NOM, as measured by DOC, is removed via ion exchange. This result is important because identifying the mode of NOM uptake by anion exchange resins is the first step in elucidating key interactions.

Impact Improved Drinking Water Quality

It is expected that this research will advance anion exchange treatment for the removal of NOM from raw drinking water. Improved NOM removal will have multiple public health benefits, such as improved treated water quality, decreased formation of halogenated organic disinfection byproducts, decreased potential for biological growth in distribution systems, and decreased facilitated transport of hazardous metals and hydrophobic organic chemicals through the treatment regimen.

Key Publications

- Boyer, T.H., Singer, P.C. (2005) Bench-scale testing of a magnetic ion exchange resin for removal of disinfection by-product precursors. *Water Research* 39(7), 1265-1276.
- Boyer, T.H., Singer, P.C. (2006) A pilot-scale evaluation of magnetic ion exchange treatment for removal of natural organic material and inorganic anions. *Water Research* 40(15), 2865-2876.

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